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AMS Tracker Thermal Control Subsystem

TTCS Safety Verification Matrix

AMSTR-NLR-PL-01
ISSUE 3.0
22-DEC-2009

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National Aerospace Laboratory (NLR)
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Document change log

<u>Change Ref.</u>	<u>Section(s)</u>	<u>Issue 1.0</u>
-	All	Initial issue
<u>Change Ref.</u>	<u>Section(s)</u>	<u>Issue 2.0</u>
-	All	50 % verifications implemented
<u>Change Ref.</u>	<u>Section(s)</u>	<u>Issue 3.0</u>
	All	First official release with verifications



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Summary

This document summarises all the TTCS safety actions and the way to verify them in a TTCS Verification Matrix.



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1 Scope of the document

The objectives of the document are:

- give an overview of the TTCS safety action items
- list the verification methods for each items
- list the due dates for delivery of safety related actions
- list the safety verification close-outs

The document will be updated and is therefore used as monitoring tool for the safety actions.



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The Matrix contains the following information:

1. Hazard Report ID (as presented by Leland Hill at the TIM April 2005). Only the TTCS relevant ID's are discussed here.

- AMS-02-F01 Structural Failure of Hardware
- AMS-02-F04 Overpressurisation of Orbiter Payload Bay/ Stored Gas inventory
- AMS-02-F05 Rupture of AMS-02 Pressurized Systems: TRD Gas System (Xe & CO₂), Cryomagnet Warm He System, Thermal Control System
- AMS-02-F10 Flammable Materials in the Payload Bay
- AMS-02-F14 EVA Operations Hazard
- AMS-02-F15 Thermal Extremes
- AMS-02-F17 Electrical Power Distribution Damage

2. Hazard Title and Description

3. Applicable requirements

4. TTCS Responsible

- the following companies are included

SYSU, AMS, UG, CAST, PDT, OHB, CGS, BE, Space Cryomagnetics, Jacobs Sverdrup, INFN and NLR.

In some cases two parties are responsible. In the matrix will be mentioned who is responsible for what part.

5. Verification Method

The verification of a safety aspect can be performed by the following methods:

D = Review of Design

T = Test

A = Analysis

I = Inspection

S = Similarity

N/A = Not Applicable

NTBT = Not To Be Tracked

The verification can be performed at component level (APS, DPS, Pump, Accumulator) at box level, TTCS level or at AMS integrated level.:

CL = Component Level

BL = Box level

TTCS = TTCS level

AMS = AMS integrated level



2 Safety Verification Matrix

1	2	3	4	5	6	7	8	9	10
Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
AMS-02-F01	Vented Volumes								
	Vented volume TTCS box	N/A	SYSU	Review of design. No enclosed volumes/open box wrapped with MLI	D	BL	ET5998-06-DRP-TTCB_Primary ET5998-08-DRP-TTCB_Secondary	DR-01 DR-01	
	Venting box MLI	JSC 65095, Multi-Layer Insulation for the Alpha Magnetic Spectrometer Requirements Document	RUAG (NOT part of this Safety data package)	MLI/blanket assembly will use standard means of venting layers and will use standoffs to provide venting across MLI/Blanket areas	I	BL	A2LM-DP-0002-AAE A MS-02 MLI Acceptance Data Package (Reference only)		
	Venting of Accumulator MLI		N/A		I	CL			Deleted from design



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
	Venting of MLI around tubes	JSC 65095, Multi-Layer Insulation for the Alpha Magnetic Spectrometer Requirements Document	RUAG (NOT part of this Safety data package)	MLI/blanket assembly will use standard means of venting layers and will use standoffs to provide venting across MLI/Blanket areas	D	TTCS	A2LM-DP-0002-AAE A MS-02 MLI Acceptance Data Package (reference only)	General p10-18 to p10-20 Drawings VSB G4370-110-718-00 VSB G4370-110-720-00 Evaporator VSB G4370-110-725-00 VSB G4370-110-730-00 TTCS lines G4370-110-735-00 G4370-110-740-00 G4370-110-745-00 G4370-110-750-00 G4370-110-755-00 G4370-110-760-00 TTCS Condenser tubes G4370-110-765-00 G4370-110-770-00 G4370-110-775-00 G4370-110-780-00	
	Venting of box fasteners	N/A	NIKHEF/INFN conceptual design NLR detailed design & documentation	Review of design. No entrapped volumes.	D	BL	ET5998-06-DRP-TTCB_Primary Details are found in ATS1225-TTCS090108-1-R0_TTCB_FMP_torquing ET5998-08-DRP-TTCB_Secondary ATS1225-TTCS090127-1-R0_TTCB_FMS_torquing	Most info in DR01, DR02, DR03, DR10 Most info in DR01, DR02, DR03, DR10	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
	Venting Tracker Radiator Fasteners	N/A	CGS/NLR	Review of design. No entrapped volumes.	D	TTCS	ET5998-09-DRP-COND-PRIMARY-WAKE-FM REV 14 ET5998-10-DRP-COND-SECONDARY-WAKE-FM REV1 ATS1225-TTCS-090716-01-R8 TTCS CONDENSER INSTALLATION	DR01 DR01	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
	Venting of Electronics boxes (copied from STD-AMS-02-F01) May 25 2007	For intentionally vented containers, vents are sized to maintain a 1.4 factor of safety for Shuttle or a 1.5 factor of safety for Station with respect to pressure loads. Meets all of the applicable pressure rates defined for one or more of the following. a) Shuttle payload bay – ICD 2-19001, Para. 10.6.1 b) Station environment – SSP 52005, paragraph 4.3 or equivalent payload specific ICD _____ c) Station PFE discharge – SSP 57000, Para. 3.1.1.4K, or equivalent payload specific ICD _____. d) Shuttle Middeck – NSTS 21000-IDD-MDK, Section 6.1.	CGS	Vented	A	BL	Included or similar to AMS-02-RP-CGS-005. Nov 12, 2004 (TBC by CGS)		



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AMS-02-F01	Rotating Equipment	NASA-STD-5003							
	Rotating impeller pump	Rotating equipment meets criteria of NASA-STD-5003 for obvious containment.	PDT	Fracture control analyses is Rotating mass assessment Verification of maximum rpm	A	CL	Analyses is included in Jacobs Sverdrup MMOD assessment on AMS02 integrated payload level 5319-1 Centrifugal pump rotating mass AMSTR-NLR-TN-062 TTCS Iss01 Commanding Monitoring and Control	All All 12,370 rpm (p41)	
AMS-02-F01	Structural Failure of Hardware								

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document	Approved	
					Method	Level	Document	Section No	RFW/ Deviations
Cause 1	Inadequate structural strength for worst-case loads during all mission phases.		SYSU (BOX) CAST (Accumulator) NLR (HX) Evaporator (NIKHEF/INFN) INFN(tubing)	Structural Analyses + vibration testing on component and box level	A&T A T T A A A	CL/BL BL BL BL CL CL	<u>TTCB Boxes</u> TTCS-SYSU-MECH-AN-009-4.0 TTCB-STRUCTURAL-ANALYSIS AMSTR-NLR-PR-30_3_0_TTCB_FM_Vibration_test_procedure VIBRPT64-1-121-S3023R.pdf VIBRPT64-2-121-S3023R.pdf <u>TTCS Accumulator</u> TTCS-SYSU-MECH-AN-004-3.0 Accumulator Structural Analysis TTCS-SYSU-MECH-AN-009-4.0- TTCB-Structural-Analysis <u>Heat Exchanger</u> AMSTR-NLR-TN-063-TTCS-HX_Structural_Analysis_report_iss01.pdf	Sections 6-9 All All All All All	

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document	Approved	
					Method	Level	Document	Section No	RFW/ Deviations
Cause 1 (cont'd)	Inadequate structural strength for worst-case loads during all mission phases.		SYSU (BOX) INFN(tubing) CAST (Accumulator) NLR (HX) Evaporator (NIKHEF)	Structural Analyses	A	CL	<p>AMSTR-NIK-TN02-Struct_Ana_AMS_Evap_ASR-D-005.pdf</p> <p>“Structural Analyses of the AMS-TTCS Evaporator Assembly”</p> <p>AMSTR-INFN-TN-001_1.0_Structural Report – Rev. A.pdf</p> <p>“Stress and frequency analysis of the evaporator new pigtailed design – Revision A”</p> <p><u>TTCS Transport tubing and bracketry</u></p> <p>AMSTR-INFN-TN-002-TTCS_TUBING_BRACKETS_STRUCTURAL ANALYSIS</p> <p>AMSTR-INFN-AN-001-TTCS_TUBE_BRACKETS_BOLTS_ANALYSES</p> <p>Set of Mathcad calculations</p>	<p>All</p> <p>All</p> <p>All</p> <p>All</p>	

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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	Tracker Radiator structural verification		CGS		A	N/A	AMS02-RP-CGS_005_Issue 4-Main radiators structural analysis report	Page 199	
	Tracker Radiator Carbon fibre struts EVA kick load evaluation		CGS (not part of TTCS)		A	N/A	(See TCS Safety Data Package)		
	Induced force by eddy current on evaporator		Space Cryomagnetism (calculate eddy currents forces)		A	TTCS			
	Strength calculation TTCS evaporator tubing for eddy current forces		NIKHEF		A	TTCS			

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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Cause 2 Cont'd	Improper Material Selection (including Stress Corrosion Cracking)	AMS-02 materials will be selected to meet the requirements of MSFC-STD-3029. Materials with high resistance to stress corrosion cracking will be used where possible. Materials with moderate or low resistance to stress corrosion cracking have MUAs that have been/will be approved for each application. Identified materials to be covered in MUAs are attached to this hazard report.		<p>Stress Corrosion Evaluation of materials list and drawings.</p> <p>Corrosion between dissimilar metals is reduced/avoided by use of primer</p>	D	CL	<p><u>Terminal Block Brackets</u> INFN-DRP-TTCS-TB-BRACKETS_20091127.zip</p> <p><u>Use of Koroporon primer</u> Recorded in ATS's of TTCS's tubes, condensers and terminal blocks</p> <p>ATS_090108_1_R0_ TTCS-P Box Integration</p> <p>ATS_090127_1_R0 _ TTCS-S Box Integration</p> <p>ATS1225-TTCS-090908_ TTCS_TTCB_Installation-R1</p> <p>ATS1225-TTCS-090107-01-Tube_Installation</p> <p>ATS1225-TTCS-090716-01_TTCS_Condenser_Installation</p> <p>ATS1225-TTCS-091024-01_TTCS Terminal Block</p> <p>ATS1225-TTCS091023_USS_clasp_brackets</p> <p>MOU's are included in the MOU overview made by Jacobs Sverdrup at AMS02 integrated payload level</p>		



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Cause 3	Initiation of propagation of flaws or crack-like defects.	The AMS-02 project will use JSC-25863A to implement the fracture control requirements of NASA-STD-5003 and SSP-30558C. See attached table for fracture classification of each structural element		Compliance with the fracture control requirements of NASA-STD-5003 and SSP-30558C will be verified by approval of fracture control summary by JSC ES4/Materials and Processes Branch.		CL	Analyses is included in Jacobs Sverdrup fracture control assessment on AMS02 integrated payload level		

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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Cause 5 cont'd	Loosening of safety critical fasteners. Fasteners back-off prevention TTCS box Primary	Safety-critical fasteners, inadvertent back-off will be prevented by the use of locking inserts/nuts, self-locking bolts, safety wire and fastener preload/torque.	AIDC/NLR	Control by self-locking inserts and self-locking bolts. Too low running torque value bolts are equipped with lock wire. Electronics connector bolts are potted. Verification by AMS02 Task sheets.	D	BL	Primary Box Drawing package ET5998-06-DRP-TTCB-PRIMARY-FM Drawing Package Heat Exchanger Primary ET6029-04-DRP-HX-P-FM Running Torque value Verification ATS_1225_090108_1_R0_ TTCS-P Box Integration + filled Record ATS1225-TTCS-081227-01 TTCS HX FMP Torquing + filled record ATS1225-TTCS-090908-01_R1 TTCS TTCB_Installation R1 AMSTR-NLR-NCR-009 Start-up radiator running torque NCR Fastener information: AMSTR_NLR_STD_001_Bolts_and_helicoils. zip	Bolts and helicoil design Bolts and helicoil design All pages All pages All pages All pages As reference	NCR/RFW



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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Cause 5 cont'd	Fasteners back-off prevention TTCS box Secondary		AIDC/NLR	Control by self-locking inserts and self-locking bolts. Too low running torque value bolts are equipped with lock wire. Electronics connector bolts are potted. Verification by AMS02 Task sheets.	D	BL	<p>Secondary Box Drawing package ET5998-08-DRP-TTCB-SECONDARY-FM</p> <p>Drawing Package Heat Exchanger Secondary ET6029-05-DRP-HX-S-FM</p> <p>Running Torque value Verification ATS_1225_090127_1_R0_ TTCS-S Box Integration + filled Record</p> <p>ATS1225-TTCS-090420-01 TTCS HX FMS Torquing + filled record</p> <p>ATS1225-TTCS-090908-01_R1 TTCS TTCB_Installation R1</p> <p>AMSTR-NLR-NCR-009 Start-up radiator running torque NCR</p> <p>AMSTR-NLR-NCR-007 Accumulator peltier bolts running torque NCR</p> <p>Fastener information: AMSTR_NLR_STD_001_Bolts_and_helicoils. zip</p>	<p>Bolts and helicoil design</p> <p>Bolts and helicoil design</p> <p>All pages</p> <p>All pages</p> <p>All pages</p> <p>All pages</p> <p>All pages</p> <p>As reference</p>	<p>NCR/RFW</p> <p>NCR/RFW</p>



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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Cause 5 cont'd	Fasteners back-off prevention TTCS box Primary QM Box		AIDC/NLR	Control by self-locking inserts and self-locking bolts. Too low running torque value bolts are equipped with lock wire. Electronics connector bolts are potted. Verification by AMS02 Task sheets.	D	BL	Primary Box Drawing package ET5998-21- DRP-TTCB-PRIMARY-QM Drawing Package Heat Exchanger Primary ET6029-01-DRP-HX-P-QM Running Torque value Verification ATS_1225_090403_1_R0_TTCB QM Box Integration + filled Record ATS1225-TTCS-090506-01 TTCS HX QM Torquing + filled record AMSTR-NLR-NCR-007 Accumulator peltier bolts running torque NCR Fastener information: AMSTR_NLR_STD_001_Bolts_and_helicoils. zip	Bolts and helicoil design Bolts and helicoil design All pages All pages All pages As reference	NCR/RFW
Cause 5 cont'd	Fasteners back-off prevention TTCS tubing brackets			Control by self-locking inserts. Verification by AMS02 Task sheets.			INFN-DRP-BRACKET-ASSY-DRAWINGS-FM Rev6 ATS1225-TTCS-090107-01-Tube_Installation	Bolts and helicoil design All pages	



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Cause 5 cont'd	Fasteners back-off prevention terminal block brackets						INFN-DRP-TTCS-TB-BRACKETS_20091127 ATS1225-TTCS-091024-01_TTCS Terminal Block	Bolts and helicoil design All pages	
Cause 5 cont'd	Fasteners back-off prevention Tracker radiator fasteners		OHB	Design control by self-locking Nutplates and bracket inserts. Verification of locking torque by ATS	D	BL	ET5998-09-DRP-COND-PRIMARY-WAKE-FM_REV1_2009_09_17 ET5998-10-DRP-COND-SECONDARY-WAKE-FM_REV1_2009_09_17 INFN-DRP-TTCS-COND-BRACKETS_20090730 ATS1225-TTCS-090716-01_TTCS_Condenser_Installation ATS1225-TTCS-090716-01-A-TTCS condenser installation RAM_Record.pdf ATS1225-TTCS-090716-01-B-TTCS condenser installation WAKE_Record.pdf	Bolts and nutplate design Bracket bolt and helicoil design All pages	
Cause 6	Loss of structural integrity of welds.						Covered by AMS-02-F05 cause 3		
Cause 7	Improper manufacture and/or assembly.						Covered by AMS-02-F05 cause 3		
AMS-02-F04	Stored Gas reservoirs								



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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	CO2 content TTCS	Max fill ratio (density): 592.4 g/l Design leak tightness	NLR	Measure fill volume and content and keep error margin to highest allowable value.	A&D	TTCS	Density definition: AMSTR-NLR-TN-044 TTCS Safety Approach Verification Primary: AMSTR-SYSU-PR-024 FM_TTCB_Filling_and_venting_procedure 2.0 P- records Verification Secondary: SYSU-PR-024 FM_TTCB_Filling_and_venting_procedure 2.0 S- records AMSTR-NLR-PR-025 TTCB He leak test procedure + records AMSTR-NLR-PR-078 CO2 leak detection procedure & Records	P21 P38 (volume = 1.433 l) P52(Mass=826.3 g) Max density based on errors 586.8 g/l P38 (volume) P52(Mass) All All	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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	FC87 content Oscillating Heat Pipe		NLR		A&D	CL	N/A		Deleted from design
	NH3 content accumulator heat pipe		CAST		A&D	CL	Verification method: AMSTR-CAST-TN-002_Acceptance_Data_Package_Iss 01.doc Verification of mass: AMSTR-CAST-VER-001_AHP_ filled_mass.docx	p16 all	
	NH3 content Tracker radiator heat pipes		CGS		A&D	N/A	Not part of TTCS ADP		
AMS-02-F05	Rupture of AMS-02 Pressurized Systems								
Cause 1	Inadequate strength for pressure and loading environments		SYSU (BOX) INFN (tubing) CAST (Accumulator) NLR (HX)				See AMS-02-F01 Structural analysis + bolts analyses		
Cause 2	Improper material selection						Material CoC of used materials.		



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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Cause 3	Improper workmanship and/or assembly	Welds are performed according to certified/qualified processes.		Approved weld procedures including pre- and post-inspection of welds and proof/burst pressure testing.			<u>Evaporator</u> AMSTR-NIK-TN-01- Reqs_Manf_and_Space_Qual_Press_weld_ASR -S-001b AMSTR-NIK-IR-01- InspectionReportLaserWeldRequalification.pdf NASA PRC0010_RevA Process Specification <u>TTCB's</u> AMSTR-NLR-PR-021_1.0 TTCS_Box_Weld_Procedure_iss064 (weld plan & material specifications) AMSTR-NLR-PR-021_1.0_TTCB_Weld_He- leak_&_Burst_Record.pdf AMSTR-AIDC-IR-01-TTCB_PT_report "Liquid penetrant reports" AMSTR-AIDC-PQR-01-TTCB-PQR "Procedure Qualification records box" AMSTR-AIDC-WPS-01-TTCB-WPS "Weld procedure specifications TTCB" <u>Accumulator</u> AMSTR-CAST-TN-002 Acceptance Data Package Iss01.doc TTCS-SYSU-TEST-TPR-014- 1_0_Accumulator_Weld_Test report.pdf	All (evaporator) All (evaporator) (reference) Section 4-7 & App C. All All All All Section 4.1 and 4.3 AppC. All (incl proof + burst)	AMSTR-NLR- NCR-011_1.0 TTCS_Accumulat or_Inlet_weld_rep air

[illegible]



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
Cause 3 (cont'd)	Improper workmanship and/or assembly	Welds are performed according to certified/qualified processes.	AIDC	Approved weld procedures including pre- and post-inspection of welds and proof/burst pressure testing.	T	CL	<u>Heat Exchanger</u> AMSTR-NLR-PR-054 HX orbital welding Procedure Issue2 AMSTR-NLR-PR-054_HX orbital welding Procedure_HX-orbital welding_Record.pdf AMSTR-AIDC-PQR-002-HX_FM_PQR.ppt "Procedure Qualification records HX FM" AMSTR-AIDC-PQR-003-HX_QM_PQR.ppt "Procedure Qualification records HX QM" AMSTR-AIDC-WPS-002-HX_FM_WPS.pdf Weld procedure specifications HX AMSTR-AIDC-IR-002-HX_weld-12.1,12.2 & Q1,Q2.pdf Inspection reports AMSTR-NLR-PR-053_01_HX_He_leak & proof pressure test procedure AMSTR-NLR-PR-53 HX welding Qualification He-leak & Proof pressure test Records AMSTR-NLR-PR-053_HX_Proof-Burst-pressure_record.ppt	All All All All All All All All All	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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Cause 3 (cont'd)	Improper workmanship and/or assembly	Brazing & Soldering is performed according to certified/qualified processes.		AIDC		CL	<u>Heat Exchanger</u> AMSTR-NLR-PR-052_HX_Brazing_Procedure & records AMSTR-NLR-PR-055_FM_HX_Start-up_heater_soldering_Procedure & records <u>Condensers</u> AMSTR-NLR-PR-041_QM-FM Condenser Manifold Brazing Procedure_issue01 & Records AMSTR-NLR-PR-040-QM-FM condenser He leak&proof press procedures_iss01 & Records AMSTR-NLR-PR-004_Cond_Manifold_Brazing_Procedure_Iss04 & Records	All All All All Page 17 (used for burst record of FM cycled sample)	
	Improper workmanship and/or assembly	Condenser gluing according to specified procedures		AIDC		CL	AMSTR-NLR-PR-038_Condenser_gluing_Procedure_06 & Records	All	
	Improper workmanship and/or assembly	Condenser Foil Heater gluing	AIDC	Approved glue procedures Heater bubble check		CL	<u>Condensers</u> AMSTR-NLR-PR-043-5_0_Condenser_heaters_installation_procedure. & Records AMSTR-NLR-PR-061_issue1.0_TTCS_Condenser_Heater_Check_Procedure.pdf	All All	

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
Cause 4	Propagation of crack-like defects						XXX		
Cause 5	Liquefaction/freezing/ thawing in lines		NLR	MDP freezing is determined by test and analyses. Proof and burst test pressure are verified and test	T & D	CL	AMSTR-NLR-TN-022 issue 2.0 Condenser Freezing Test Plan AMSTR-NLR-TN-39 Condenser freezing Test Report AMSTR-NLR-PR-007_TTCS_High_Press_Sample_Test_procedure_Iss01.pdf AMSTR-NLR-TR-007_TTCS Condenser High Pressure Test Report_Iss01	All All All All	
Cause 5	Liquefaction/freezing/ thawing in other than condenser lines		CAST	Other (non-condenser) TTCS lines will not be frozen in all environmental conditions	A Thermal Analysis show non-freezing temperatures	BL	ESCG-4470-06-TEAN-DOC-0032 Alpha Magnetic Spectrometer (AMS-02) Tracker Thermal Control System (TTCS) Cold Environment Temperatures	All	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
Cause 5	Liquefaction/freezing/ thawing in lines		CAST	The TTCS Accumulator Heat Pipe is filled with 3 grams of ammonia and will not reach temperatures that can freeze the ammonia. NOTE: Even if the ammonia were capable of freezing, the straight pipe construction with interior mesh and fill quantity of the heat pipe would preclude an accumulation of a solid block of ammonia.	A Thermal Analysis show non-freezing temperatures	BL	ESCG-4470-06-TEAN-DOC-0032 Alpha Magnetic Spectrometer (AMS-02) Tracker Thermal Control System (TTCS) Cold Environment Temperatures	P7 and Appendices	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document	Approved	
					Method	Level	Document	Section No	RFW/ Deviations
Cause 6	Improper filling or over filling		NLR	TTCS loop MDP calculation and verification liquid quantity) Volume and mass verification by measurements	A	TTCS	MDP : AMSTR-NLR-TN05 Iss03 TTCS System Design Description MDP density: AMSTR-NLR-TN044 Iss 1.2 Verification: AMSTR-NLR-TN-019-Issue 2.0: TTCS Fill System and Accuracy Verification Primary: AMSTR-SYSU-PR-024 FM_TTCB_Filling_and_venting_procedure 2.0 P- records Verification Secondary: SYSU-PR-024 FM_TTCB_Filling_and_venting_procedure 2.0 S- records	3.1.7 P21 All P38 (volume) P52(Mass) P38 (volume) P52(Mass)	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
	Accumulator Ammonia heat Pipe, MDP and verification		CAST	Verification liquid quantity	A & S	CL	AMS02-CAST-TTCS-ACC-DR-002_DESIGN OF TTCS ACCUMULATOR_CAST Verification of temperature: TTCS-SYSU-AN-001-6.0_TTCS-Accumulator Thermal Safety Analysis.pdf	Table 15 (MDP = 50.2 bar is in between 2 presented values) p46	
Cause 7	Valve enclosure verification (not altering the MDP)		NLR		D	TTCS	Valves are deleted from design AMSTR-NLR-TN-TN05 Iss03 TTCS System Design Description	Schematic on P11	N/A



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
Cause 8	TTCS Heater Failure		SYSU/NLR	Only accumulator temperature can drive the TTCS pressure to MDP. Other locations will only force the local liquid to an alternate location. Accu heaters have two-fault tolerant heater circuitry. Analyses of TTCS to failure response operations					

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document	Approved	
					Method	Level	Document	Section No	RFW/ Deviations
Cause 8 cont'd	TTCS Heater Failure		NLR/AIDC	<p>Thermal analyses TTCS loop MDP calculation</p> <p>Max. Temperatures verifications</p> <p>Threshold values TTCS thermostats</p> <p>Review of heater thermostatis design and values</p>			<p><u>Overall MDP</u> MDP : AMSTR-NLR-TN05 Iss03 TTCS System Design Description MDP density: AMSTR-NLR-TN044 TTCS Safety Approach</p> <p><u>Uncontrolled component zones max temperatures</u> TTCS-SYSU-SIMU-AN-005-Safety-Analysis-TTCB.pdf</p> <p><u>Unctrolled heated zones in TTCS</u> AMSTR-NLR-TN044</p> <p><u>TTCS Thermostat treshold values</u> AMSTR-NLR-TN-043_4.0_TTCS_Heater_Specificati on</p> <p><u>Accumulator thermal switch treshold values</u> TTCS-SYSU-AN-001-6.0_TTCS-Accumulator Thermal Safety Analysis.pdf</p>	<p>3.1.7</p> <p>P21</p> <p>Section 3</p> <p>Section 7.9</p> <p>Appendix 06</p> <p>All summary in section 9 & 10</p>	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
Cause 8 Cont'd	TTCS Heater Failure			<p>Review of heater thermostats design and values</p> <p>Review of Tracker radiator heater thermostats and env maximum</p> <p>Functional test Thermal Switches</p> <p>Proper installation of Thermal switches</p> <p>Functional test TTCB installed Thermal Switches</p>			<p><u>Heat Exchanger thermal switch set-point</u> AMSTR-NLR-TN044 TTCS Safety Approach</p> <p><u>Tracker radiator/condenser maximum temperature</u> AMSTR-SYSU-SIMU-PR-005-1.0_Radiator_condenser_model_results.ppt</p> <p><u>Incoming Inspection</u> AMSTR-AIDC-PR-019_1_0 TTCS_TS_Incoming_Inspection Procedure and records</p> <p>AMSTR-AIDC-PR-037_Thermal Switchand Sensor Gluing Integration procedure & records</p> <p><u>Integrated functional Check TTCB</u> TTCS-SYSU-TEST-TRP-016-2.0_TTCB_QM_Test_Report.pdf</p>	<p>7.3.1 (update needed to clarify)</p> <p>Page 8</p> <p>All</p> <p>All (Y = boxes) (A = condensers) TBF (C = DS sensors CERN) TBF</p> <p>Section 6.4 (QM)</p>	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document	Approved	
					Method	Level	Document	Section No	RFW/ Deviations
Cause 8 Cont'd	Overheating Tracker radiator rod maximum temperature < 100 C	Keep CFRP rod < +100 C	NLR		A	CL	AMSTR-NLR-TN-061 TTCS Liquid line health heater calculations	5.4.2 5.5.1 5.6	
					T		NLR_Proposal_5339 TTCS Condenser Heater Design Verification	Proposed test Section 2-5	
Cause 9	Micrometeoroid Orbital Debris (MMOD) Susceptibility analysis TTCS accumulator needs to be included (0.9999 probability over one year)		Jacobs Sverdrup/NASA		A	N/A	Is included in Jacobs Sverdrup MMOD assessment on AMS02 integrated payload level		
Cause 10	TTCS COPV compliance with S-080 and S-081	ANSI/AIAA S-080 ANSI/AIAA S-081	NLR	No COPV objects in the design	A	TTCS	N/A		
Cause 10	TTCS accumulator compliance with S-080 and S-081	ANSI/AIAA S-080 ANSI/AIAA S-081	CAST	No COPV objects in the design	A	CL	N/A		

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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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	TTCS Pressure log Maintenance (set-up)		SYSU	During all TTCB- testing pressure relief valves are used. Verification picture Verification picture Exception: During vibration testing T-logging is used. After filling of completed TTCS during AMS02 transport by AMS T-loggers.	I	TTCS	AMSTR-NLR-PR-060 issue_1.2_TTCScomponent_box_thermal_vacu um_test_plan. AMSTR-NLR-PIC-001-TV_Relief_valve.jpg AMSTR-NLR-PR- 029_TTCB EMC EMI_procedure_PartB Issue 2.0 AMSTR-NLR-PIC- 002_TTCB_P EMC_PR_valve.JPG AMSTR-NLR-PR-030 Iss3.0 TTCB_FM_Vibration test procedure & Records AMS02 Temperature log HiG/LoG During storage and transport	P10 in schematics Visual verification Figure 4-2 Visual verification P31 Last page of records TBF	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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	Tracker Radiator Heat Pipe MDP calculation and verification		CGS/Iberespazio		S/T/A (TBD)	N/A	See TCS Safety Data Package		
AMS-02-F10	Flammable Materials in the Payload Bay								
	Oscillating Heat Pipe flammable liquid (Not applicable FC087 is inert)	N/A	NLR						Deleted from design
AMS-02-F14	EVA Operational Hazards								
AMS-02-F14	Sharp edges TTCS boxes (seems not relevant TBD)	N/A	SYSU	N/A TTCS is hidden behind main wake radiator and USS	D & I	BL	AMSTR-NLR-TN-005-Issue03 TTCS_System_Design_Description	P49	



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
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	Gloved hand contact at Tracker radiators meet temperature requirements.	a) Within EVA touch temperature range of -18 Degrees C. (0 Degrees F.) and 49 Degrees C. (120 Degrees F.) and satisfies the intentional contact constraints of letter MA2-95-048 (if applicable). b) Meets EVA touch temperature criteria of NSTS 07700 Vol. XIV App. 7.	SYSU	Radiator/Condenser heaters are thermostatically controlled at -15 C Orbital environmental extreme <<+49 C	A	TTCS	AMSTR-NLR-TN-043 TTCS Heater Specifications Iss 4.0 TTCS-SYSU-SIMU-PR-004-1.0 Radiator_condenser_model_description AMSTR-SYSU-SIMU-PR-005-1.0_Radiator_condenser_model_results	P69 All P6	
AMS-02-F15	Thermal extremes								
	Thermal extremes TTCS box Hot case (T < +65 °C, MDP) Cold case (T > -55 °C, freezing) in all conditions		SYSU		A	BL			



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Hazard Report ID	Hazard Title & Description	Applicable Requirements	TTCS Responsible	Hazard Control	Verification Method		Reference document		Approved
					Method	Level	Document	Section No	RFW/ Deviations
	Thermal extremes TTCS Radiator (T < +65 °C, MDP) in all conditions		SYSU	Radiator/Condenser heaters are thermostatically controlled. Orbital environmental extreme is much lower. Ground extreme is monitored see AMS-02-F04	A	TTCS	AMSTR-NLR-TN-043 TTCS Heater Specifications Iss 4.0 TTCS-SYSU-SIMU-PR-004-1.0 Radiator_condenser_model_description AMSTR-SYSU-SIMU-PR-005-1.0_Radiator_condenser_model_results	P69 All P6	
	Thermal extremes TTCS Condenser uncontrolled heating in frozen conditions (T < -5 °C, MDP)			MDP freezing verified by test. Hazard control thermostats. Environmental extreme calculated			AMSTR-NLR-TN-39 Condenser Freezing Test Report Iss 3.0 AMSTR-SYSU-SIMU-PR-005-Radiator condenser model results Iss 1.0	P27 P6	
AMS-02-F17	Electrical Power Distribution								

[illegible]





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